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OPTOMAGNETIC STUDIES OF TRIPLEX DNA NANOSWITCHES

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Magnetic bead-based DNA processing provides a basic principle for DNA selection [1] that was used in microreactors for DNA computing [2]. A combination of DNA self-assembled nanostructures with pH switching of DNA conformations may lead to pH-dependent delivery systems and artificial cell architectures. We report on the switching of magnetic nanobead (MNB) clusters via DNA triplex structures (Fig. 1a) detected using an optomagnetic technique. The 2nd harmonic modulation of 405 nm laser light transmitted through the sample container is measured as a function of the frequency *f* of an applied oscillating magnetic field (Fig. 1b). This modulation arises from the coupled magnetic and optical anisotropies of 100 nm MNBs. The frequency spectra reflect the rotation response of the MNBs and show characteristic features at frequencies related to their inverse hydrodynamic size that allows one to detect DNA-target induced agglutination of different populations of MNBs [3]. Here, we use a single population of MNBs functionalized with palindromic polypyrimidine DNA oligonucleotides that may spontaneously fold in the presence of polypurine DNA to form a triplex structure that links MNBs (Fig. 1a).

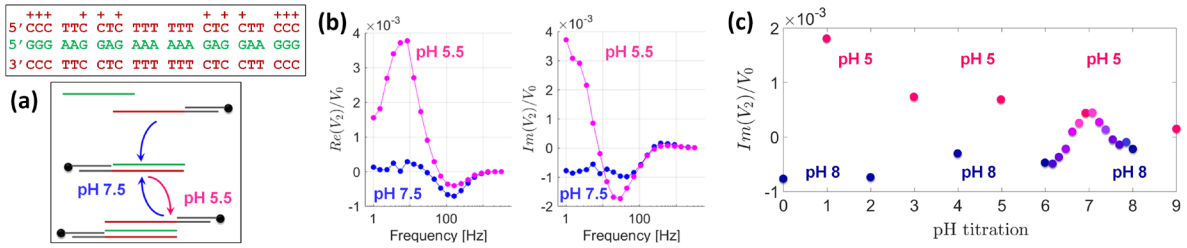

Fig. 1: optomagnetic detection of triplex DNA nanoswitches. **(a)** Schematic illustration of the pH-dependent triplex folding of biotinylated pyrimidine sequences (red), bound to streptavidin coated MNBs via adaptor strands (grey), in the presence of the complementary purine DNA target (green). **(b)** In-phase (Re) and out-of-phase (Im) 2nd harmonic transmitted light signal V_2 normalized with average intensity of transmitted light, V_0, obtained after 1 min incubation in a magnetic field of 20 mT for the indicated pH values. **(c)** DNA-mediated assembly upon pH switching, followed by 1 min magnetic incubation and observed in $\mathrm{Im}(V_2)/V_0$, at f = 1-10 Hz. The 100 nm MNBs (0.1 mg/ml) were saturated with the pyrimidine DNA probes (10 nM) and the target concentration was 5 nM.

The reaction time of intermolecular triplex folding was reduced to 1 min using magnetic incubation in 20 mT such that the total time for incubation and measurement was about 3 min. Fig. 1c shows the signal from an experiment starting at pH 8, where no triplex DNA was formed. Subsequently, acid and base were sequentially added (left to right in figure) to vary the pH between stable and unstable conditions for triplex formation. The nanoswitches are observed to behave reversibly and to be clearly detectable in the optomagnetic signal. The effect is reduced upon repeated pH switching due to screening from salt formed from the acid-base reaction. This could be avoided by electronically switching pH [4].

In conclusion, we present triplex DNA nanoswitches with a sensitive lock-in based detection scheme of polypurine DNA target. Reversible DNA immobilization on MNBs with sensitive optical detection may provide a useful building block in DNA computation architectures. This work was supported by FP7 projects ECCell (#222422), MATCHIT (#249032), and DFF project (#4184-00121B).

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